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HUBBLE SPACE TELESCOPE SERVICING MISSION CONTAMINATION CONTROL REQUIREMENTS

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Acronyms

ACS	Advanced Camera for Surveys
AS	Aft Shroud
ASIPE	Axial Scientific Instrument Protective Enclosure
ASTM	American Society of Testing Materials
CCIP	Contamination Control Implementation Plan
CMP	Contamination Master Plan
CCP	Contamination Control Plan
COSTAR	Corrective Optics Space Telescope Axial Replacement
CVCM	Collected Volatile Condensable Material
ES	Equipment Section
ESD	Electrostatic Discharge
FGS	Fine Guidance Sensor
FSS	Flight Support System
FS&S	Flight Systems and Servicing
GFE	Government Furnished Equipment
GSE	Ground Support Equipment
HST	Hubble Space Telescope
JSC	Johnson Space Center
MOLEKIT	Molecular Kinetics
NASA	National Aeronautics and Space Administration
NICMOS	Near Infrared Camera Multi-Object Spectrograph
NVR	Non-Volatile Residue
ORI	Orbital Replacement Instrument
ORU	Orbital Replacement Unit
ORUC	ORU Carrier
OTA	Optical Telescope Assembly

Acronyms (Continued)

PIP	Payload Integration Plan
RIU	Remote Interface Unit
RSIPE	Radial Scientific Instrument Protective Enclosure
RSU	Rate Sensing Unit
SA	Solar Array
SAC	Second Axial Carrier
SI	Scientific Instrument
SIPE	Scientific Instrument Protective Enclosure
SM	Servicing Mission
SSE	Space Support Equipment
SSM	Support Systems Module
STIS	Space Telescope Imaging Spectrograph
TML	Total Mass Loss
TQCM	Temperature-Controlled Quartz Crystal Microbalance
TV	Thermal Vacuum
UV	Ultraviolet
VAP	Verification Acceptance Program
WF/PC	Wide Field/Planetary Camera

1. INTRODUCTION

This document defines the contamination control requirements for the Hubble Space Telescope (HST) Servicing Mission (SM) orbital replacement hardware, and associated support equipment. SM hardware shall include: Orbital Replacement Units (ORUs), Orbital Replacement Instruments (ORIs), Space Support Equipment (SSE), and specific pieces of the Ground Support Equipment (GSE). Implementation of the requirements contained herein will generally be accomplished via the following methods: adequate design of the hardware; instituting proper controls during fabrication, assembly, integration, and testing operations; performing necessary operations to lower potential contamination levels of hardware (i.e., vacuum bakeouts, cleaning, bagging, purging, etc.); and providing necessary monitoring and cleanliness verification checks throughout all operations.

1.1 CONTAMINATION CONTROL PLANS

Contamination Control Plans (CCPs) shall be developed and submitted to the HST Flight Systems and Servicing (FS&S) Project for approval. The HST FS&S Project shall designate the organization responsible for each CCP. Each CCP should address contamination control criteria from assembly through installation on HST and on-orbit operations. The hardware manufacturer shall be responsible for meeting the requirements of this document upon delivery to the customer (HST FS&S). However, since contamination control plans may affect the hardware design, it is recommended that the CCPs be completed and that implementation commence during the project design stage. Individual Scientific Instrument (SI) performance requirements and their respective contamination requirements through end-of-life shall be included in the SI CCPs.

1.2 APPLICABILITY

This document specifies the contamination requirements for four general classes of SM hardware:

1. Internal Aft Shroud (AS) Components. These components include ORUs, ORIs, SSE, crew aids, or tools used in or located within the AS of the HST. A more detailed definition and specific requirements are found in Sections 3.4.1 and 3.4.1.1, respectively.
2. Non-AS contamination sensitive hardware. This includes ORUs, ORIs, SSE, crew aids, or tools that have degradable optics or sensors, or have a direct line of sight to a contamination sensitive surface on the HST. A more detailed definition and specific requirements are found in Sections 3.4.2 and 3.4.2.1, respectively.
3. External AS hardware. This includes ORUs or SSE located external to the AS of the HST. A more detailed definition and specific requirements are found in Section 3.4.3.
4. Carrier SSE. Carrier is defined as the Flight Support System (FSS), the Orbital Replacement Unit Carrier (ORUC), or the Second Axial Carrier (SAC). A more detailed definition and specific requirements are found in Section 3.4.4.

NOTE: SSE is used interchangeably with Carrier SSE

Any hardware that is located within or directly affects a future contamination sensitive ORU, ORI, or SSE shall meet the requirements specified for the higher assembly, including the AS. The contamination requirements shall also apply to future rework or modification of orbital replacement equipment.

1.3 APPLICABLE DOCUMENTS

The following documents are applicable to STR-29:

1. MIL-STD-1246, Product Cleanliness Levels and Contamination Control Program.
2. D-STD 209,Clean Room and Work Station Requirements, Controlled Environment.
3. ASTM E-595, Methods of Test, Total Mass and collected Volatile Condensable Materials from Outgassing in a Vacuum Environment.
4. STM E-1559, Standard Test Method for Contamination Outgassing Characteristics of Spacecraft Materials.
5. GSFC-TLS-PR 7324-01, Contamination Control Procedure for Tape Life Sampling of Surfaces
6. NASA Reference Publication 1124, Outgassing Data for Selecting Spacecraft Materials, Revision 2, August 1987
7. LMSC ST/SE-26, HST Thermal Vacuum Bakeout, Appendix E, July 7, 1989
8. MDSSC-7324-440, Hubble Space Telescope Contamination Analysis: The Planned Servicing Mission for 1993: Shuttle Contingent of the SAC, ORUC, and FSS, February 7, 1992
9. LMSC EM: SPS 654A, HST Hub Area Contamination Analysis, Reference Table III and IV, May 29, 1992.
10. CONT/EER-242-008, Predicted Contamination Levels on the HST due to OTA ES, SSM ES, and Sas, 5 August 1993.
11. LMSC EM:FS&S 778, Assessment of Contamination Effects of Power Tools Outgassing during EVA, Revision A, 1 April 1993.
12. LMSC TSS-531, Analysis on Molecular Contamination in the HST Hub Area for SM-2, 15 November 1995.
13. LMMS EM: FS&S 975, HST Contamination Model Update and Implications for Flight Hardware Bakeout, 30 October 1995.
14. LMMS EM: FS&S 1226, RSU Effects on HST Hub Outgassing Environment, 29 July 1996.
15. JSC SN-C-0005, Contamination Control Requirements for the Space Shuttle Program, Revision C, 15 February 1989.

2. SCOPE

This document establishes the contamination requirements for the general classifications of SM hardware. These requirements shall address material screening and selection, surface cleanliness levels, molecular outgassing and vacuum bakeout requirements, facility environmental requirements, needs for special contamination control measures and equipment, and identification of required contamination control documentation.

2.1 UNSPECIFIED REQUIREMENTS

The HST FS&S Project is responsible for establishing the contamination requirements based on the specific application of the hardware for an individual component or subsystem unit that is supplied by a contractor and delivered to the HST FS&S Project or delivered to another contractor as Government Furnished Equipment (GFE) without specified contamination requirements.

3. CONTAMINATION CONTROL REQUIREMENTS

3.1 MATERIAL SCREENING AND SELECTION

Materials selected for the HST, HST ORU, HST ORI, or SSE shall meet the minimum vacuum outgassing screening criteria as tested according to the American Society of Testing Materials (ASTM) E-595 (i.e., have a maximum total mass loss [TML] of 1.0 percent and a maximum collected volatile condensable mass [CVCM] of 0.10 percent). In general, a material is qualified on a product-by-product basis. However, for any material for which lot variation is suspected, such as high outgassing non-metallic materials (e.g., paints, epoxies, etc.), the HST FS&S Project may require each lot to be tested. In such cases, material approval for each lot is contingent upon the test results. The National Aeronautics and Space Administration (NASA) Reference Publication 1124 (revision 2) provides data on various spacecraft materials that were tested according to ASTM E-595.

Although a material meets the screening criteria, it may be inappropriate for use around sensitive hardware. If the material TML and CVCM levels approach the allowable limits, and/or if source and receiver temperatures fluctuate, and/or if large amounts of the material are used, the HST FS&S Project shall approve the use of this material. The technical data required by the HST FS&S Project includes: the amount of material used, the location of the material, the TML and CVCM levels, and the deposition rate, if known, of the material.

When material outgassing rates need to be established at source and receiver temperatures other than those specified in ASTM E-595, the Molecular Kinetics (MOLEKIT) facility at GSFC, or an equivalent facility approved by GSFC, such as that described in ASTM E-1559, shall be utilized.

The use of silicone materials shall be minimized for all HST hardware and support equipment. All proposed bagging materials shall be approved by the HST FS&S Project.

3.2 SURFACE CLEANLINESS REQUIREMENTS

3.2.1 HST Surface Requirements

The surface cleanliness requirements for the SM hardware are specified in terms of allowable particulate and molecular contamination. All surface requirements must be verified by test and/or analysis at various points in the integration, test, and launch readiness phases. These verification points shall be identified in the CCP. The requirements shall be applicable during ground handling, transportation, prelaunch, and launch operations. Further definitions of surface cleanliness requirements as applied to specific applications are as follows.

3.2.1.1 External AS Items and Carrier SSE. The ORUs and SSE that are located outside of the AS shall be certified visibly clean highly sensitive using a white light inspection method. The visibly clean highly sensitive acceptance criteria is "the absence of particulate and molecular contaminants as seen with the unaided eye using oblique white lighting with an intensity of 100-125 foot-candles at an observation distance of 6-18 inches." This is equivalent to the NASA Johnson Space Center (JSC) SN-C-0005, "Visibly Clean Highly Sensitive" criteria. The surface molecular (non-volatile residue [NVR]) requirement shall be ≤ 2.0 mg/ft2 (i.e., Level B per MIL-STD 1246). The use of a ultraviolet (UV) light source (wavelength = 3660 Å) for inspection of surfaces is recommended as an effective means for achieving the visibly clean highly sensitive criteria.

Certification of the hardware molecular level shall include the identification of the molecular species present in the sample.

Certain contaminant species may be more detrimental to HST at levels below 2.0 mg/ft2. For these cases, acceptance of surface molecular contamination will be based on HST FS&S Project approval.

3.2.1.2 Internal AS Components. Hardware that will be located or used inside the AS shall meet Level 400B per MIL-STD 1246. MIL-STD-1246 specifies the requirements for surface particulate and surface molecular contamination. Internal levels of an ORI or ORU shall either be set by the instrument developer with the approval of the HST FS&S Project or meet the standard Level 400B. Hardware that comes in contact with items located in the AS shall meet the above requirement (i.e., the interior surfaces of the Scientific Instrument Protective Enclosure [SIPE], crew aids, and tools).

3.2.1.3 Non-AS Contamination Sensitive Hardware. ORUs, ORIs, or SSE that have degradable optics or sensors, or have a direct line of sight to a HST contamination sensitive surface shall be as clean as the specified contamination sensitive hardware and must meet the higher level of cleanliness requirements. In general, hardware with degradable optics (SIs, sensors, trackers, etc.) will have more stringent surface cleanliness requirements than a Level 400B. The specific requirements for each of these elements shall be set by the hardware developer with the approval of the HST FS&S Project and documented in the CCP.

3.2.1.4 Hardware to be Used at a Higher Level of Assembly. Surface particulate and molecular contamination requirements for hardware to be used at a higher level of assembly (such as an ORI) shall meet the requirements placed on the higher level of assembly. This will only apply to hardware when deemed necessary due to a performance requirements, and shall be based on an analysis performed by the instrument developer and approved by the HST FS&S Project. ORI hardware surfaces must meet a minimum surface cleanliness requirement of Level 400B per MIL-STD 1246.

No requirements may be placed on hardware already installed on HST.

3.2.2 GSE in Contact with ORUs, ORIs, or SSE

Any GSE that comes in contact with flight hardware shall meet the same surface cleanliness requirements as that particular hardware to prevent cross contamination. Appropriate cleanliness constraints (such as bagging or isolating selective surfaces) must be applied to GSE in the immediate vicinity of flight hardware.

3.2.3 Orbiter Surface Requirements

The surface cleanliness requirements for the Orbiter Midbody (payload bay) are specified in terms of allowable particulate contamination. All exposed surfaces of the Orbiter Midbody (payload bay and payload bay doors) shall be cleaned and inspected prior to the HST SM payload integration. This requirement is stated in the Payload Integration Plan (PIP). Additional controls such as UV inspection of reflown blankets shall be specified in the PIP and detailed in the Launch Site Contamination Control Implementation Plan.

3.2.4 Certification of Surface Particulate Cleanliness

The certification of surface particulate levels shall be accomplished via one or more of the following methods: white light inspection, UV light inspection, tape-lift inspection (using approved tape), image analyzer evaluations, and other substitute methods which have specific project approval. All planned methods and sampling locations should be documented in the CCP and approved by the HST FS&S Project.

3.2.5 Certification of Surface Molecular Cleanliness

The certification of surface molecular cleanliness levels shall be made by NVR swab analysis of the selected surface or from analyzing contaminants accumulated during a solvent rinse of the flight hardware. The rinse method is the preferred method because, generally, larger surface areas may be evaluated. The optimum surface area for swabbing or rinse sampling is 1 ft2 (0.1 m2) depending on the geometry and material composition of the hardware. Proposed sampling areas and procedures shall be documented in the CCP and submitted to the HST FS&S Project for approval. Other certification methods may be employed, but procedures must first be submitted to the HST FS&S Project for approval.

3.2.6 Hardware Design

The hardware shall be designed for ease of cleaning and to avoid collection and trapping of particulates. Prior to any assembly operation that precludes further cleaning and inspection, the surfaces shall be cleaned, inspected, certified, and documented. This includes hardware with either visibly clean or quantitative level measurement certification. After this cleaning of future non-accessible areas, the cleaned areas shall be protected from recontamination by covers, bagging, purging, etc. Witness samples must be placed and kept near this hardware for the remainder of the hardware activities to facilitate monitoring of "representative surfaces" for particulate and surface NVR levels.

3.3 ENVIRONMENTAL REQUIREMENTS

All ORUs, ORIs, SSE, and critical GSE shall be maintained in temperature and relative humidity controlled cleanroom environments per FED-STD 209. This requirement applies from subassembly integration of the flight hardware and extends through ground processing, transportation, prelaunch, and launch operations. Since most hardware fabrication is not performed in a controlled environment, fabrication and some limited subassembly work may be performed in generally clean environments. Such hardware shall be cleaned, verified, and double bagged prior to admittance into a cleanroom environment and prior to fit checks or integration with clean hardware.

3.3.1 Class 100,000 Requirements

As a minimum, a Class 100,000 environment per FED-STD 209 shall be maintained for all hardware unless a more stringent requirement applies. The temperature shall be between 65° F and 80° F, and the relative humidity shall be between 30 percent and 50 percent. The temperature range is established to prevent condensation on the hardware at 50 percent relative humidity. The lower limit of the relative humidity is an Electro-Static Discharge (ESD) constraint. The hardware shall be covered at all times by an HST approved material unless operations preclude it. Operations that preclude covering hardware shall be documented and approved by the HST FS&S Project.

3.3.2 Class 10,000 Requirements

A Class 10,000 environment or better per FED-STD 209 shall be maintained for ORUs, ORIs, SSE, and GSE which are to be located or used in the internal AS or come in contact with items used inside the AS. The temperature shall be between 65° F and 80° F and the relative humidity shall be between 30 percent and 50 percent. This hardware shall be protected from contamination by HST FS&S Project approved material unless operations preclude it. Operations that preclude covering the hardware shall be documented and require approval by the HST FS&S Project.

Class 10,000 cleanrooms must have a continuous particulate monitoring capability to determine the air quality specified as particles per cubic foot of size equal to or greater than particle size shown. Continuous monitoring will be required when sensitive components are exposed; the particle monitors shall have audible alarms, set to specified limits, so that personnel will be alerted when activities in the cleanroom or external to the filter intake have resulted in high particle levels.

The Class 10,000 cleanroom must also have continuous hydrocarbon monitoring capability to determine the air quality around sensitive hardware. Continuous monitoring will be required when sensitive components are exposed to alert personnel of activities in the cleanroom or external to the filter intake that may potentially affect exposed surfaces. Prior to the introduction of hardware into the cleanroom, the cleanroom must be baselined for hydrocarbons. The nominal cleanroom operating hydrocarbon level shall not exceed 15 ppm (measured as CH_4).

A witness plate monitoring program shall be implemented in the cleanroom areas. Both particle and NVR witness plates shall be installed in the cleanroom areas to evaluate accumulation of contaminants. Details of the witness plate program (type of plates, methods of measurement, and frequency of sampling) shall be addressed in a ORI, ORU or SSE CCP or Contamination Control Implementation Plan (CCIP).

3.4 MOLECULAR OUTGASSING CERTIFICATION REQUIREMENTS

Any hardware, including the ORIs, ORUs and SSE can represent a potential contamination threat to sensitive optical components on the HST due to bulk material outgassing. In order to reduce this risk, an outgassing certification shall be performed on all SM hardware. The requirements for each hardware location element shall be set according to hardware location and application on the HST: internal AS components; external AS components; non-AS contamination sensitive components; or SSE used for on-orbit transport of sensitive flight hardware.

For a detailed summary of past outgassing data for the Optical Telescope Assembly (OTA), SIs, and Support Systems Module (SSM) bakeouts, consult Appendix E of "HST Thermal Vacuum Bakeout", document [7] in the Applicable Documents Section.

Separate outgassing certification criteria for the Carriers are delineated in "HST Contamination Analysis: The Planned Servicing Mission for 1993, Shuttle Contingent of the SAC, ORUC, and FSS", refer to document [8] and are summarized in Section 3.4.5. Complete outgassing certification test plans shall be written by the responsible hardware developer and submitted to the HST FS&S for review and approval six months prior to testing. After testing, all outgassing certification results for each hardware element shall be summarized and submitted to the HST FS&S Project for review and approval.

3.4.1 Internal AS Components

The following hardware is considered contamination sensitive: hardware that is contained or used inside the AS; hardware that comes in direct contact with or is located within the immediate vicinity of items contained in the AS; hardware with degradable optics or sensors; and any other hardware designated as such by the HST FS&S Project. (Major instrument elements such as the Advanced Camera for Surveys [ACS], Corrective Optics Space Telescope Axial Replacement [COSTAR], Fine Guidance Sensor [FGS], Near Infrared Camera and Multi-Object Spectrometer [NICMOS], Space Telescope Imaging Spectrograph [STIS], and Wide Field/Planetary Camera [WF/PC] shall comply with the acceptance criteria.)

These AS requirements are based on past SI history during the Verification Acceptance Program (VAP) performed at GSFC as related to the most sensitive cold surface in the AS and the primary mirror reflectance degradation requirement of the HST. The RSUs or other hardware, such as the crew aids or tools, which enter the

AS, but are not themselves contamination sensitive shall be evaluated by analysis on a case by case basis.

3.4.1.1 Internal AS Contamination Sensitive Components – Contamination Acceptance Criteria. During vacuum operations a chamber pressure of < 10-5 Torr shall be maintained for the duration of the test. The contamination acceptance is based on molecular deposition measurements of a temperature-controlled quartz crystal microbalance (TQCM). During certification, the temperature of the hardware shall be 10° C above the maximum on-orbit operating temperature. The TQCM crystal temperature shall be 10° C below the minimum on-orbit operating temperature of the most sensitive surface as determined by analysis. These test parameters are summarized in Table 3-1.

The HST contamination acceptance criteria is a ~~an~~ surface outgassing rate less than 1.56 x 10-9 g/cm2-hr as measured on a 15 MHz TQCM crystal averaged over an 8 hour period. The corresponding maximum TQCM frequency change shall be calculated based on the TQCM view factor to the hardware.

The optimum method of monitoring the hardware to achieve the Table 3-1 requirements is to use a test box inside the vacuum chamber to measure the total hemispherical contribution (mass per unit time) of the hardware.

In the event a test box is unavailable, the field of view of the TQCM shall be completely filled by the hardware under test. To accurately determine the hardware outgassing rate, the TQCM shall be located in or as close to a vent (if applicable) as practical, thus isolating the chamber contributions to the TQCM. The acceptance criteria shall reflect the surface area of the TQCM field of view and not the hardware surface area.

Table 3-1

Internal AS Contamination Sensitive Components Contamination Acceptance Criteria Test Summary

Test Parameter	Test Condition
Test Chamber Pressure	< 10-5 Torr
Hardware Temperature	10° C above the maximum on-orbit operating temperature
TQCM Crystal Temperature	-20° C
Criteria Period	8 hours
TQCM Outgassing Rate	1.56 x 10-9 g/cm2-hr [15 MHz crystal rate of 1 Hz/hr/cm2] averaged over an 8 hour period

The criteria period may be reduced if the HST FS&S Project concludes that the TQCM frequency change and rate of change indicates negligible outgassing from the hardware.

3.4.1.2 Internal AS Noncontamination Sensitive Components - Contamination Acceptance Criteria. The Rate Sensing Units (RSUs) or other hardware, such as the crew aids or tools, which enter the AS, but are not themselves contamination sensitive shall demonstrate that they will not be a contamination source in the AS. This hardware will be evaluated by analysis on a case by case basis; however general guidelines have been established.

Hardware such as crew aids or tools which enter the AS, but will not be integrated into the AS, shall meet the following requirements. For all metallic crew aids or tools no outgassing certification is required. Crew aids or tools which use small amounts of nonmetallic materials (e.g., lubricants) shall be evaluated on a case by case basis or meet criteria of an outgassing rate less than 117.0 x 10-9 g/cm2/hr as measured on a 15 MHz TQCM averaged over and 8 hour period. This measurement corresponds to a maximum TQCM frequency of 75 Hz/hr. Tools which operate at high temperatures in the AS, such as the power tools, shall be evaluated by analysis, to determine their impact to sensitive AS surfaces. The crew aid and tool criteria are summarized in Table 3-2.

The RSU outgassing levels have been assessed by analysis and have been found to not significantly contribute to the molecular flux within the hub area (Reference Document 13). Based on these anlyses, a contamination requirement for the RSUs or any other ORU which will enter the AS and reside on the equipment shelf with the RSUs shall meet a collective outgassing requirement of less than 23.4 x 10-9 g/cm2-hr as measured on a 15 MHz TQCM, averaged over an 8 hour period. This correspondes to a maximum TQCM frequency change of 15 Hz/hr/cm2 (averaged over 8 hours). The outgassing measurements shall be made as described in Section 3.4.1.1 and

Table 3-2

Crew Aid and Tool Contamination Acceptance Criteria

Category	Acceptance Criteria
All Metallic Crew Aids and Tools	None
Crew Aids and Tools with Nonmetallic Materials	75 Hz/hr measured on a -20° C TQCM or by evaluation
Power Tools	By Analysis

Table 3-1. The outgassing rates of individual RSUs or ORUs shall be book kept by the Observatory Manager and ORU responsible engineer and reported in the contamination certification documentation.

3.4.1.3 HUB Area Contamination. All SIs occupy or view some portion of the HST hub area, and are therefore subject to and contribute to the contamination levels within. Any SI that is inserted into the HST will impact the hub area contamination levels and shall be assessed through analyses and relevant outgassing tests. The sensitivity of the hub area is based on the contamination sensitivity of the SIs. The outgassing rate requirement will be constrained by the sensitivity of the SI as determined through analysis. The hub area applicable analyses (Reference Documents 9, 11-14) document the the maximum acceptable outgassing rates for the COSTAR, FGS, NICMOS, STIS, and WF/PC-2 based on measured outgassing certification data or assumed venting areas. These measured outgassing certification rates are based on a collection temperature at -65° C.

The ORI or ORU outgassing certification measurements must measure the total hemispherical contribution of the ORI or ORU. All hardware that resides in the hub area must demonstrate through HST FS&S Project approved testing that the total outgassing rate in the hub area is not exceeded at any time for any mission hardware complement. In the event that any hardware installed in the Hub area exceeds the maximum acceptable outgassing rates based on -65° C, duty cycles based on SI performance periods shall be determined.

3.4.2 Non-AS Sensitive Hardware

Hardware that is external to the AS, but is designated contamination sensitive, shall meet the requirements specified below. This includes hardware: that has a direct line of sight or communication to a sensitive surface; that poses a threat to the performance of an ORU, ORI, optical, or thermal surface; or hardware that is designated such by the HST FS&S Project. Items such as the Axial and Radial Scientific Instrument Protective Enclosures (ASIPE and RSIPE, respectively) fall into this category. Document [6] of the Applicable Documents illustrates such components along with a summary of the vacuum test results.

3.4.2.1 Non-AS Sensitive Hardware – Contamination Acceptance Criteria. Contamination acceptance is based on the contamination requirements of the most sensitive surface which contacts or views the non-AS sensitive hardware. The contamination acceptance criteria for the SIPEs is an outgassing rate less than 1.56 x 10-9 g/cm2-hr as measured on a 15 Mhz TQCM crystal averaged over an 8 hour period. This measurement corresponds to a maximum TQCM frequency of 1 Hz/hr/cm2 (averaged over 8 hours). This period may be reduced if the HST FS&S Project concludes that the TQCM frequency change and rate of change indicates that there is no significant outgassing from the hardware. The temperature of the hardware shall be 10° C above the maximum on-orbit operating temperature during certification, and the temperature of the TQCM shall be 10°C below the minimum operating temperature of cold HST optics and critical sensitive surfaces. The hardware electronics, if applicable, shall be turned on during thermal vacuum certification to effectively assess the outgassing characteristics; however, this requirement may be waived on a case by case basis considering allowable thermal limits and allowable unit run time.

3.4.3 External AS Components

Hardware that is contained outside of the AS, that does not contain any sensitive optics or sensors, and that does not have a direct line of sight to contamination sensitive hardware or impact thermal control surfaces shall demonstrate "no significant outgassing" as defined in the OTA Equipment Section (ES) and SSM

ES modeling analysis (Reference Document 13). This definition applies to items such as: in-bay electronics and batteries in the OTA ES and SSM ES. Since the criteria stated in 3.4.2.1 is considered too stringent for this application, a separate modeling analysis shall be performed as in Section 3.4.5. An outgassing rate has been assigned to each OTA ES and SSM ES bay. All items within the bay may not collectively exceed the bay outgassing requirement. This allows some ORUs to have a higher outgassing rate, while other ORUs in bays with multiple items will have lower outgassing rates for identical ORUs. The outgassing rates for each ORU shall be book kept by the Observatory Manager and the ORU responsible engineer and reported with the ORU outgassing certification documentation. The outgassing requirements for the OTA ES and SSM ES are summarized in Table 3-3.

The Solar Arrays (SAs) will be modeled to determine the long-term outgassing effects on the HST. The analysis will estimate the outgassing rate necessary in order not to impact a sensitive component from molecular flux through the component or bay venting.

3.4.4 Carrier SSE Vacuum Contamination Requirements

As noted in Section 1.2, the word Carrier refers to the SAC, ORUC, or the FSS. The allowable TQCM deposition rates for the carriers during vacuum contamination certification has been established by a computer modeling analysis of a SM scenario. The results of this analysis can be found in Reference Document 8 and is summarized in Table 3-4.

3.4.5 Alternate Vacuum Testing Contamination Monitors

In the event a 15 MHz TQCM is not available, a 10 MHz or other TQCM may be utilized for hardware certification, subject to the approval of the HST FS&S Project. Sensitivities of the TQCM shall be taken into account for the certification criteria.

Table 3-3

HST OTA ES and SSM ES Bay Outgassing Requirements

Location	Bay Outgassing Requirement
OTA Bay B	100 Hz/hr
OTA Bay C	100 Hz/hr
OTA Bay D	100 Hz/hr
OTA Bay E	100 Hz/hr
OTA Bay F	100 Hz/hr
OTA Bay G	100 Hz/hr
OTA Bay H	100 Hz/hr
SSM Bay #1	500 Hz/hr
SSM Bay #2	1000 Hz/hr
SSM Bay #3	1000 Hz/hr
SSM Bay #4	500 Hz/hr
SSM Bay #5	500 Hz/hr
SSM Bay #6	500 Hz/hr
SSM Bay #7	500 Hz/hr
SSM Bay #8	500 Hz/hr
SSM Bay #9	500 Hz/hr
SSM Bay #10	500 Hz/hr
SSM Bay -V2	500 Hz/hr
SSM Bay +V2	500 Hz/hr

Table 3-4

Carrier SSE Contamination Acceptance Criteria Test Summary

Test Parameter	Test Condition
Test Chamber Pressure	< 10-5 Torr
Hardware Temperature	10° C above the maximum on-orbit operating temperature
TQCM Crystal Temperature	-20° C
Criteria Period	8 hours
TQCM Outgassing Rate	114 x 10-9 g/cm2-hr [75 MHz crystal rate of 1 Hz/hr/cm2] averaged over an 8 hour period

3.4.6 Cold Finger Condensate Sample

It is recommended that a "cold finger" be used during thermal vacuum (TV) testing. In the event there is a problem in meeting the program requirements in Section 3.4.1.1, 3.4.3, or 3.4.4, a solvent rinse can be performed on the cold finger and the wash chemically analyzed to aid in determining the outgassing species and sources.

3.5 PROTECTION/PACKAGING

Following thermal vacuum certification, all hardware shall be protected from surface recontamination. This applies to integration onto GSE and SSE. All SSE surfaces and hardware flight containers shall be contamination certified to the contained hardware cleanliness level and maintained in a verifiable clean state through integration and launch.

3.6 PURGES

The SSE shall provide the availability of purge gas to Scientific Instruments and ORUs, as required. The purity and flow rates of the gas shall be set in accordance with the requirements of the SI or ORU. The purge supply and delivery system shall be tested and the particulate and molecular cleanliness of the gas exiting the system shall be certified according to SI requirements. Refer to each SI CCP for specific purge requirements.

A mission specific purge plan shall specify the requirements of the purge carts to meet the SI and ORU purge requirements. The purge system contamination requirements shall be controlled through the purge plan.

4. CONTAMINATION CONTROL PLANS

Contamination control plans are necessary to ensure that the contamination requirements described herein are met during each mission phase. These contamination control plans shall outline the methods for complying with the HST SM contamination requirements.

4.1 HST SM CONTAMINATION MASTER PLAN

The HST SM Contamination Master Plan (CMP) provides a common framework for individual Contamination Control Implementation Plans. The CMP lists the program approved materials, groups the mission specific hardware in accordance with the hardware designations defined herein, provides system level contamination budgets, and describes the general manufacturing, assembly, integration, testing and on-orbit guidelines for implementing contamination controls.

This plan shall provide uniform control, monitoring, and reporting methodology for all SM hardware from subassembly through delivery, rework, storage, mission integration, launch, on-orbit operations, and return.

4.2 CONTAMINATION CONTROL IMPLEMENTATION PLAN

A SM CCIP shall be written by the hardware contractor for specified ORUs or SSE that outlines the methods for compliance with the requirements described herein. Each plan shall provide uniform control, monitoring, and reporting methodology for all SM hardware from subassembly through delivery, rework, storage, mission integration, launch, on-orbit operations, and return. These CCIPs shall describe activities, as appropriate, from design through on-orbit operations. This plan shall cover as a minimum, the following:

- Contamination budgets for the delivered system
- Certification of Personnel – ESD, Cleanroom
- Methodology and frequency of cleaning, inspection, and certification, and sequence of operations
- Environment definition and traceability
- TV contamination criteria using TQCM data
- Contamination violation reporting and assessment of effects
- Packing material criteria, cleanliness levels, and procedures
- Transportation and storage controls for ensuring contamination protection and monitoring
- Cleanroom garments, controls, and monitoring
- ORI/ORU throughput measurement
- Purge gas monitoring

4.3 CONTAMINATION CONTROL PLAN

A SM CCP shall be written by an ORI hardware contractor that outlines the methods needed for complying with the requirements described herein for a specific ORI or element. This plan shall provide uniform control, monitoring, and reporting methodology for all SM hardware from subassembly through delivery, rework, storage, mission integration, launch, on-orbit operations, and return. These CCPs shall describe activities, as appropriate, from design through on-orbit operations. This plan shall cover as a minimum, the following:

- Contamination budgets for the delivered system
- Certification of Personnel – ESD, Cleanroom
- Methodology and frequency of cleaning, inspection, and certification, and sequence of operations
- Environment definition and traceability
- Contamination outgassing criteria using TQCM data

- Contamination violation reporting and assessment of effects
- Packing material criteria, cleanliness levels, and procedures
- Transportation and storage controls for ensuring contamination protection and monitoring
- Cleanroom garments, controls, and monitoring
- ORI/ORU throughput measurement
- Purge gas monitoring

5. REQUIRED CONTAMINATION CONTROL DOCUMENTATION

Written documentation outlining compliance with the requirements contained in Section 3.1 shall apply to and accompany each flight hardware item, GSE container, SSE, and packaging material.

5.1 HARDWARE CLEANLINESS DOCUMENTATION

The necessary surface cleanliness documentation shall include results of visual inspection and direct surface measurement data, including the following:

- Hardware cleanliness logs
- Historical summary of cleanliness measurements (when taken, type, and results)
- Cleanings performed (when, how, why and post-cleaning results)
- Anomaly history
- Witness plate results
- Particulates
- NVR
- Purge gas specifications

5.2 MOLECULAR OUTGASSING CERTIFICATION

The thermal vacuum outgassing certification shall include the following:

- Summary of outgassing and certification test set-up and operations
- Summary of certification results
- TQCM type and data
- Test temperatures

- Chamber background levels
- Witness mirror results
- Cold finger results (if any)

5.3 ENVIRONMENTAL MONITORING

The environmental monitoring shall include the following:

- Temperature
- Relative humidity
- Airborne classification and particle counter results
- and molecular accumulations
- Summary of hydrocarbon monitor data
- Anomaly summary

5.4 ANOMALIES

All anomaly situations that impact the specified cleanliness requirements shall be documented. The HST FS&S reserves the right to approve/disapprove hardware which may be detrimental to the program.

APPENDIX A

DEVIATIONS AND WAIVERS

REQUEST FOR DEVIATION / WAIVER

930722

HST FLIGHT SYSTEMS AND SERVICING PROJECT
GODDARD SPACE FLIGHT CENTER
GREENBELT, MD. 20771

STR-29 HST RSM CONTAMINATION CONTROL REQUIREMENTS

RIU OUTGASSING CERTIFICATION

N/A

N/A

REMOTE INTERFACE UNIT (RIU)

N/A

None if approved.

None if approved.

None

STR-29 Paragraph 3.4.1.3 Contamination Acceptance Criteria requires a hardware temperature of 10°C above the maximum orbit operating temperature (30°C) during the duration of the contamination acceptance test.

RIU S/N 012 bake out results indicate that a significant amount of bake out time would be required to achieve the 10°C margin. The contamination acceptance outgassing rate of less than 1 Hz/hr., averaged over 8 hours, was achieved at the 30°C operating temperature. This RIW is required for the WFPC-II.

RIU S/N 012

Deputy Project Manager
Flight Systems and Servicing

R. K. [signature]

A.1. GSFC HW-W-001 RIU Outgassing Certification